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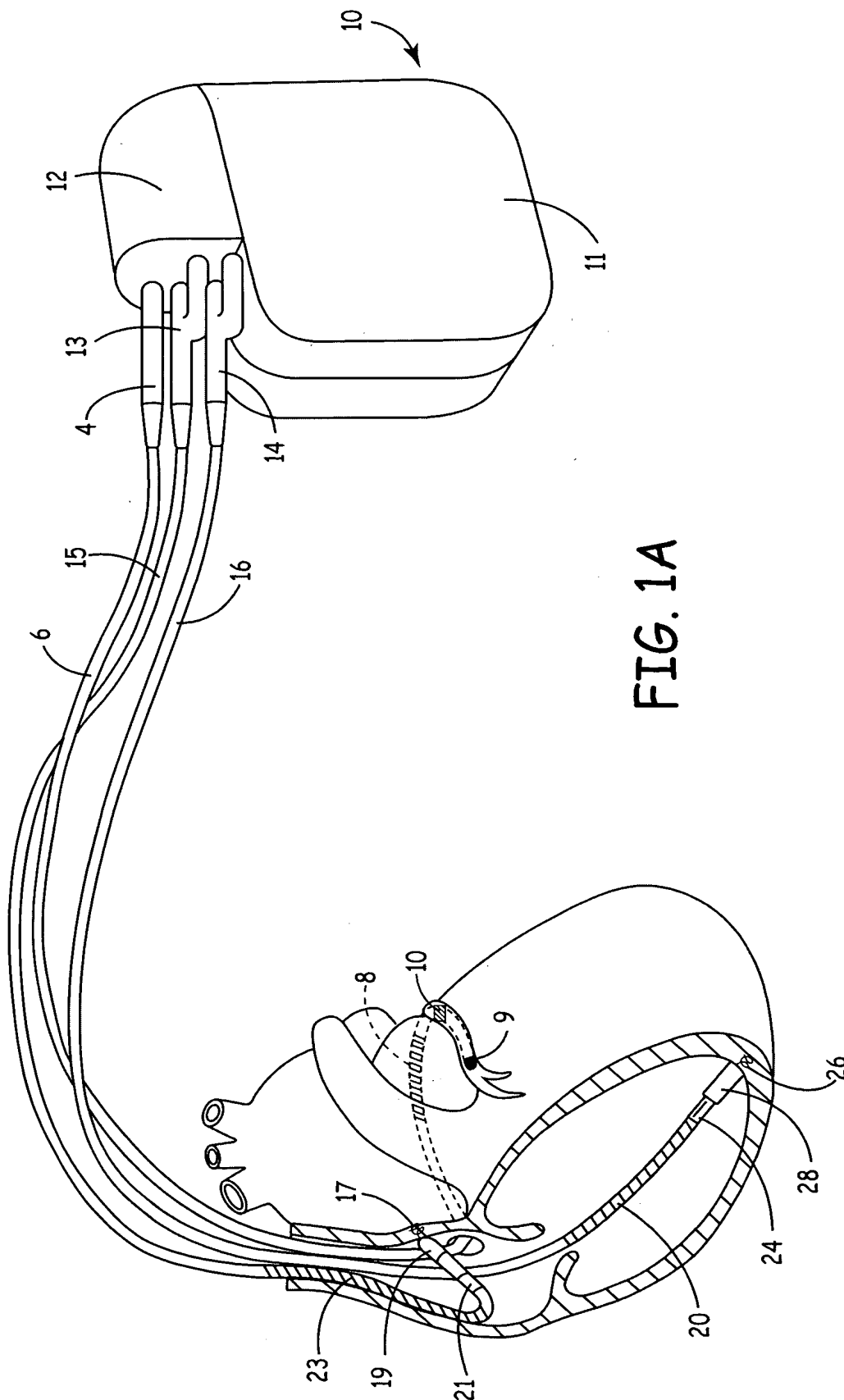


FIG. 1A

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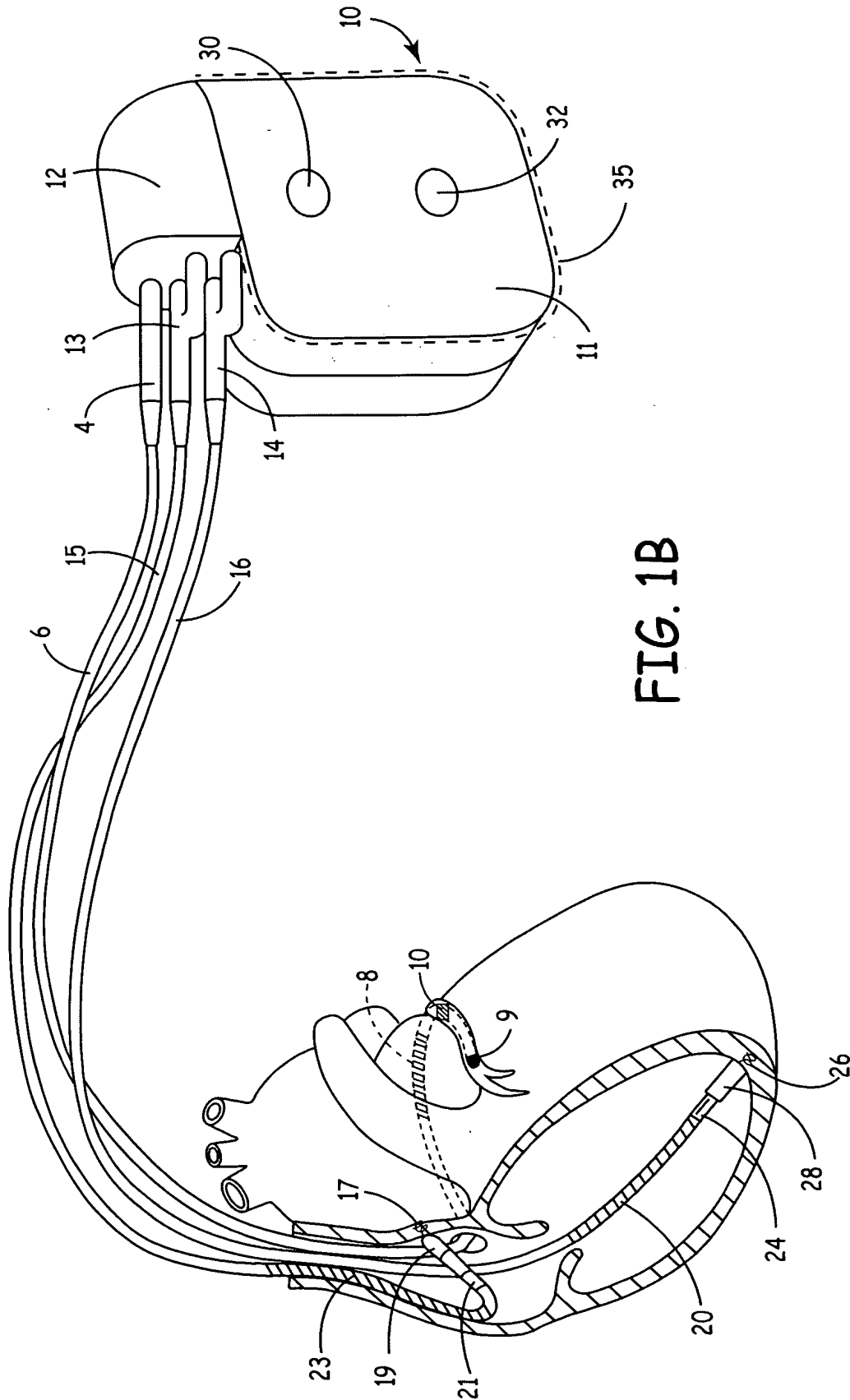


FIG. 1B

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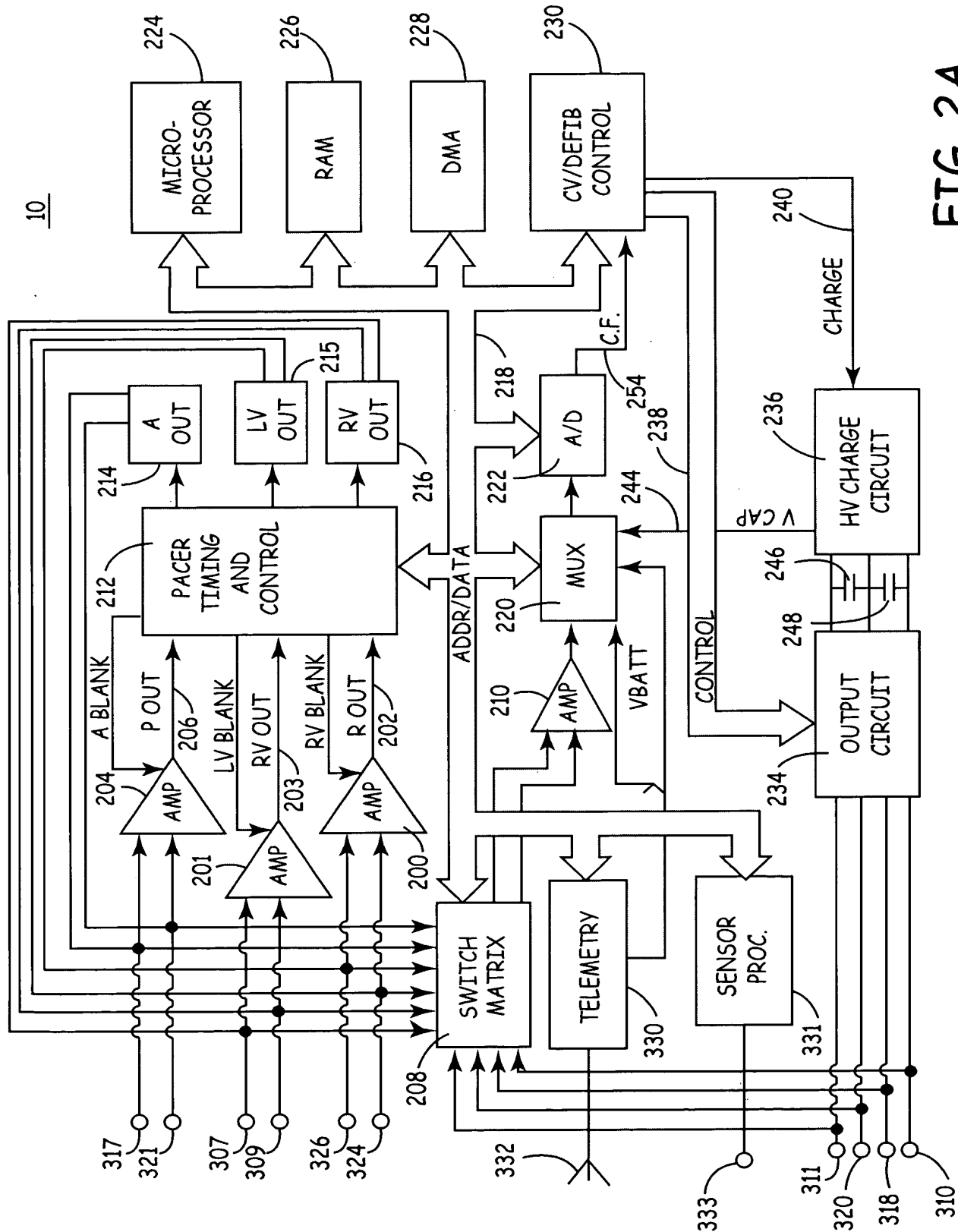


FIG. 2A

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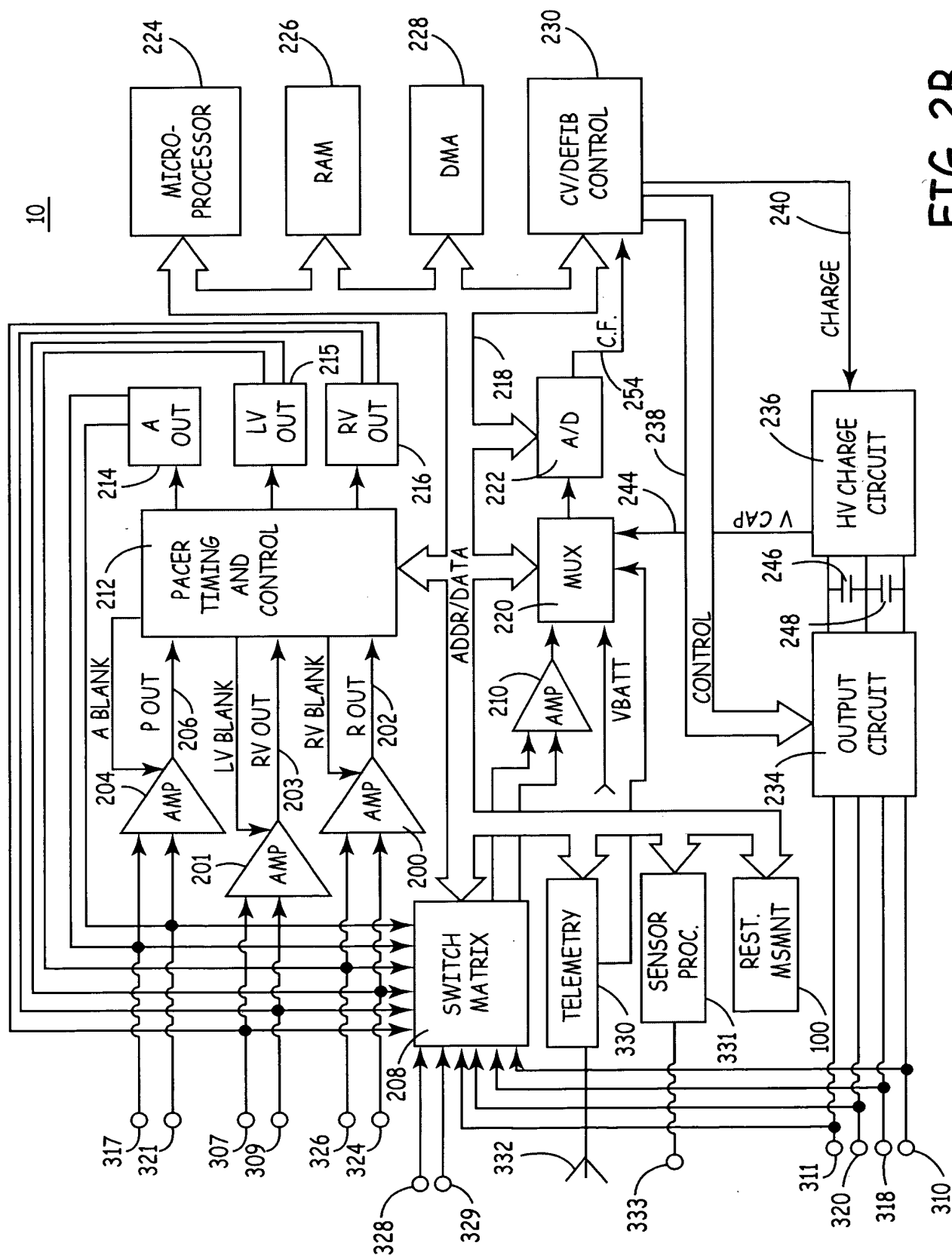
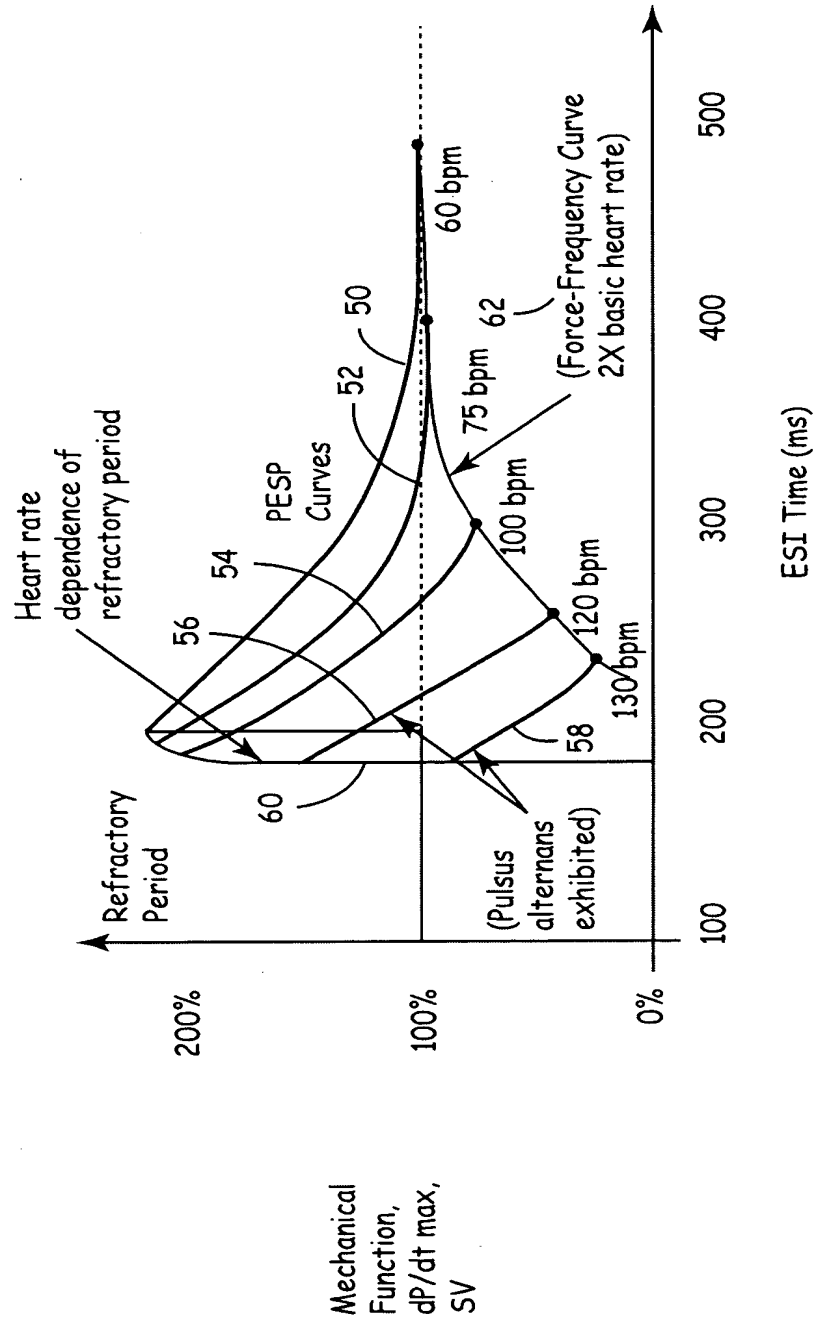


FIG. 2B

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FIG. 3

• Interdependence of mechanical function and rate with  
 extrasystolic interval (ESI)





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## Optimal ESI Timing and Heart Rate

- Sweet spot, balancing safety and effect, narrows and moves closer to refractory period as rate increases
- Upper rate limit necessary for CPT
- Adjustment of ESI with rate not necessarily identical to refractory or QT interval change with rate, depending on strategy and upper rate limit
- Importance of tracking refractory period

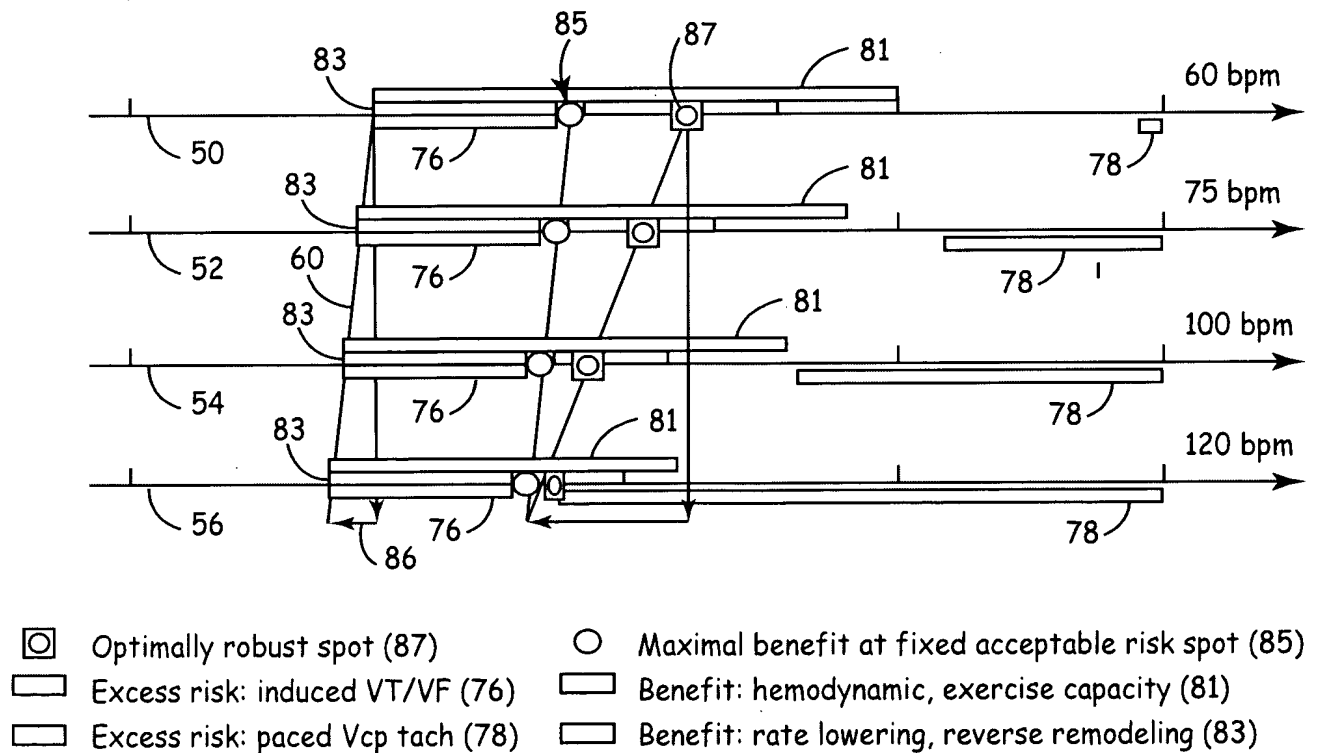
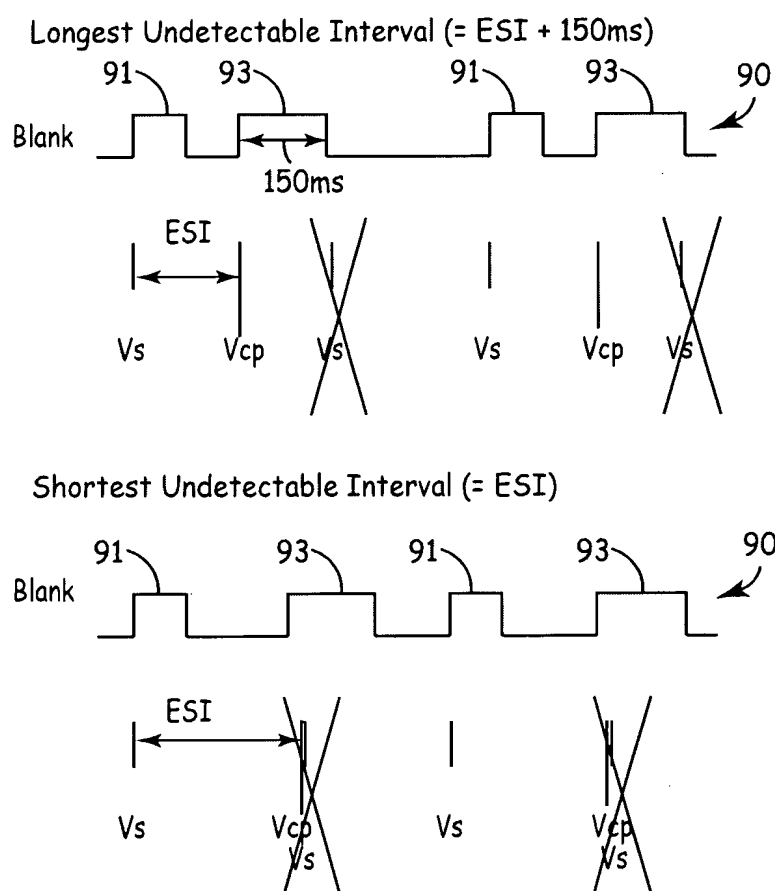


FIG. 5

FIG. 6





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## FIG. 7

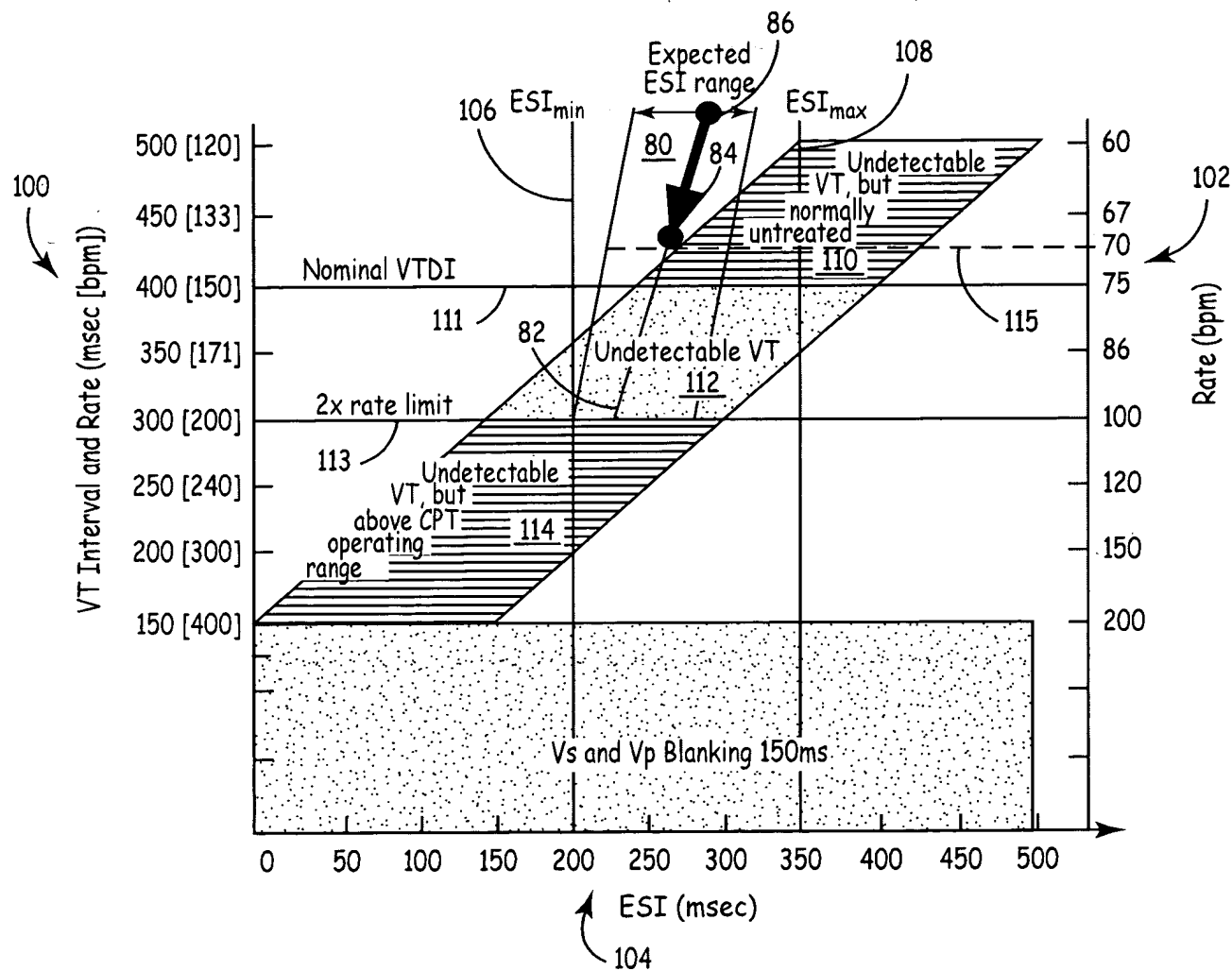
### Proposed Solutions

- Periodically drop ESS
  - Implementation of M of M+1 reveals VT after median delay of M/2 ESS cycles
  - Investigate reducing M at higher rates
  - Consider M = infinity (always on) if rate low enough. (m=0, always off, is already achieved at high rates via ESS rate limit safety rule.)
  - Can speed detection of VTs that are not 2:1 but are close and start with a phase that would otherwise delay their detection
- Suspend ESS upon inappropriate Asense timing
  - Safety rule engages with loss of AV synchrony during most VTs
- Dither timing of A-A or A-V intervals though A or V pacing
  - Occasional variations of 50-100 ms either way (if blanking is short) may be sufficient to enable hidden VT detection
- Auxiliary sensing vector
  - Use Coil-to-Can or other low polarization EGM signals to detect Vsense in blanking window
  - Discriminate by time or morphology from expected CPT evoked response
- Look for rate Irregularity as a clue to hidden VT
  - As VT rate enters/leaves undetectable VT zone, CPT rate will abruptly halve/double (perhaps exceeding upper rate limit)
- Reduce blanking/refractory
  - Moves left hand limit to the right (see diagram)
  - Incomplete solution by itself, since Vcp is intended to cause a prompt depolarization which needs to be blanked
  - Perhaps complete solution if implement electronic blanking of known time/morphology evoked R waves but not VTs (see auxiliary sensing vector note)
  - Two fold increase of change of R-R interval at base mechanical rate per change of blanking significantly adds to heart rate range over which VTs can be detected without dropping ESS beats
  - In principle, atrial cross chamber blanking can be made short enough (a few ms) to never hide a VT
  - Could be accomplished with low polarization leads or sense amp electronics modifications.
  - May be combined with auxiliary sensing vector solution
- Deliver ESS with short ESI
  - Enhances window for VT detection (particularly at a low ESS rates)
- Keep ESS upper rate limit low
  - Caps aliased VT rates. Upper limit 75 bpm makes all VTs faster than nominal VTDI detectable
  - Exploit in conjunction with reducing blanking and short ESIs (see above) to be least restrictive
  - Use an appropriately lower rate limit if Vpacing and not Vsensing to account for propagation differences.

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# FIG. 8

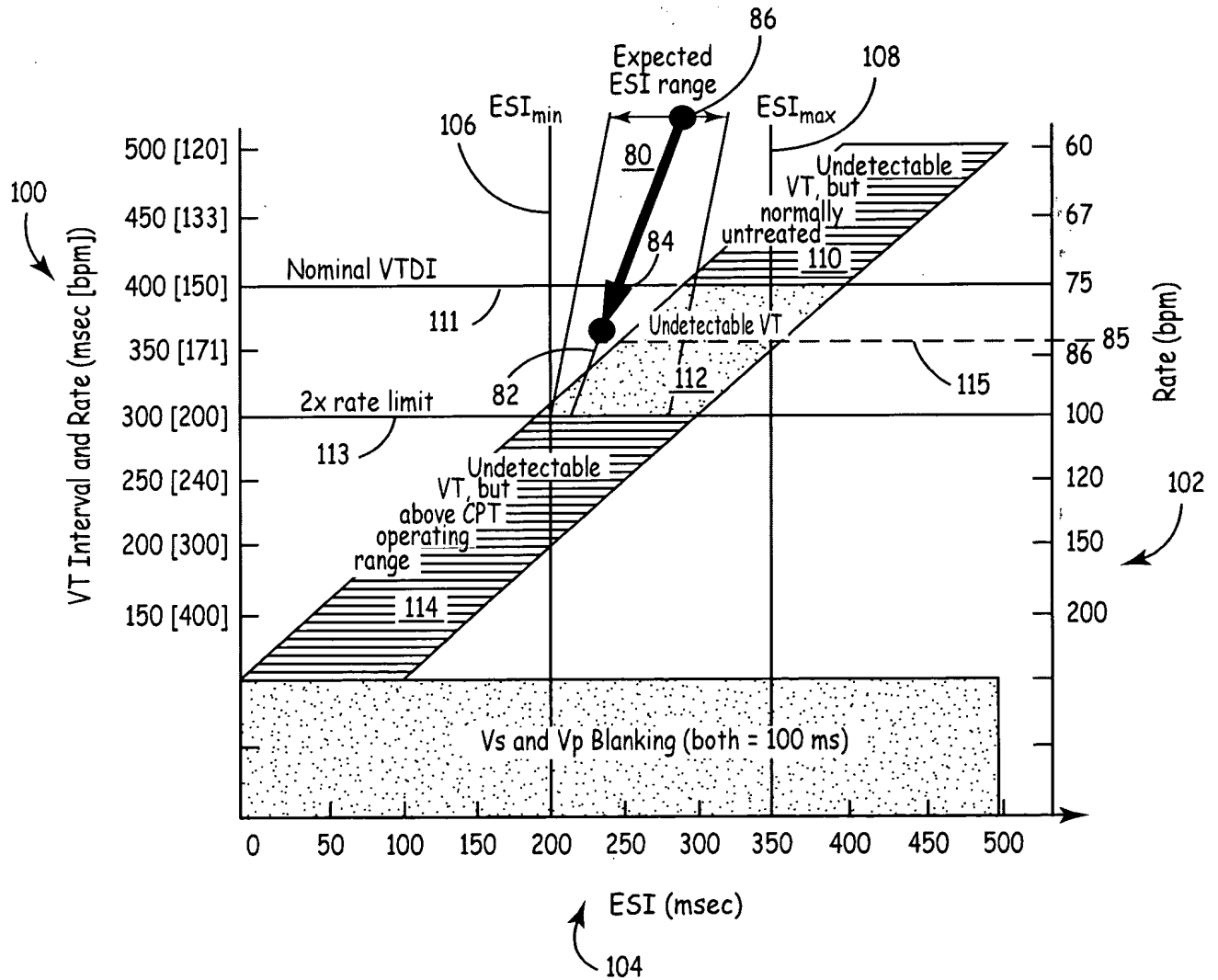
VT Detection and Operating Range (to 70 bpm)



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FIG. 9

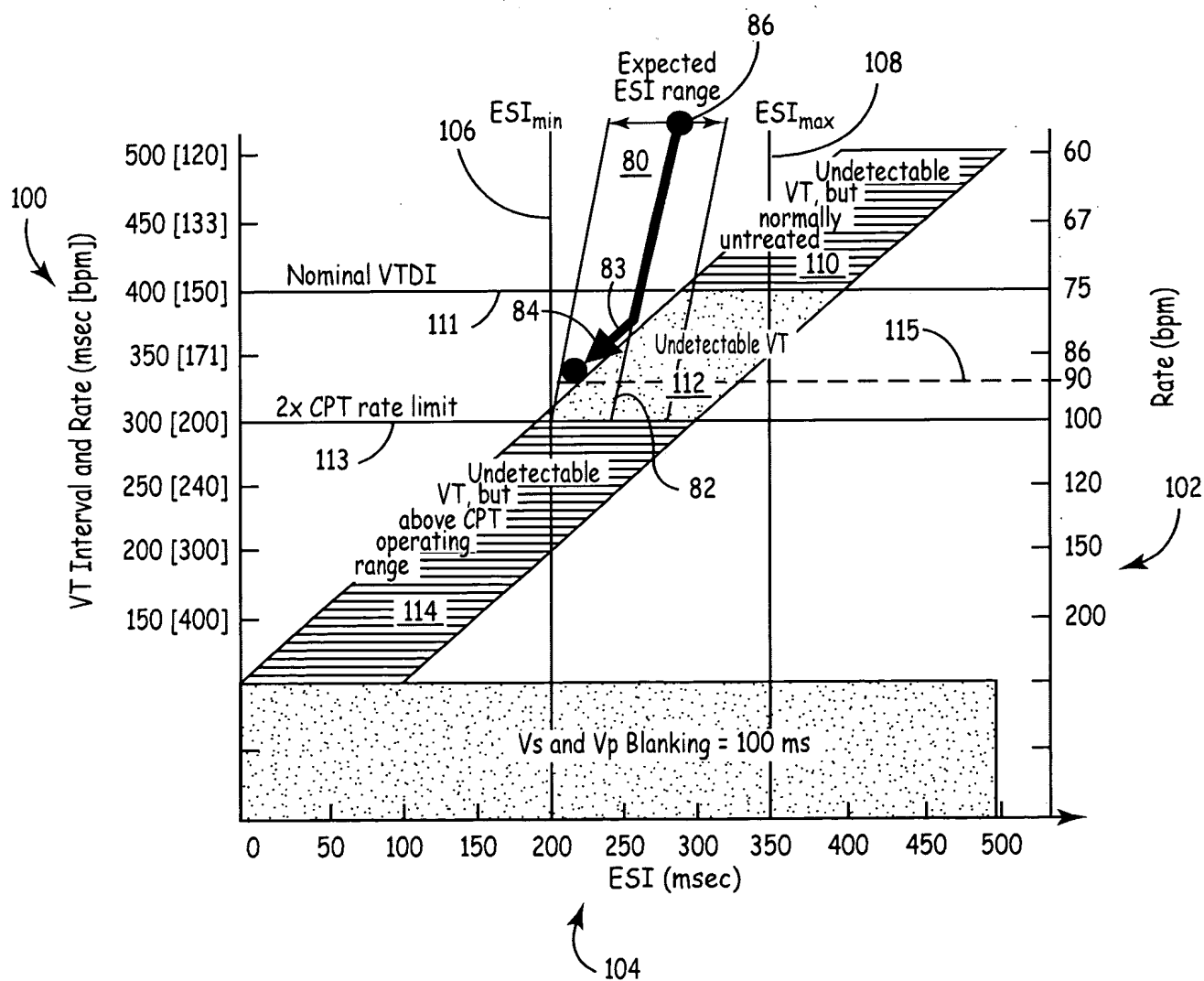
VT Detection and Extended Operating Range (to 85 bpm with shorter Blanking)



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FIG. 10

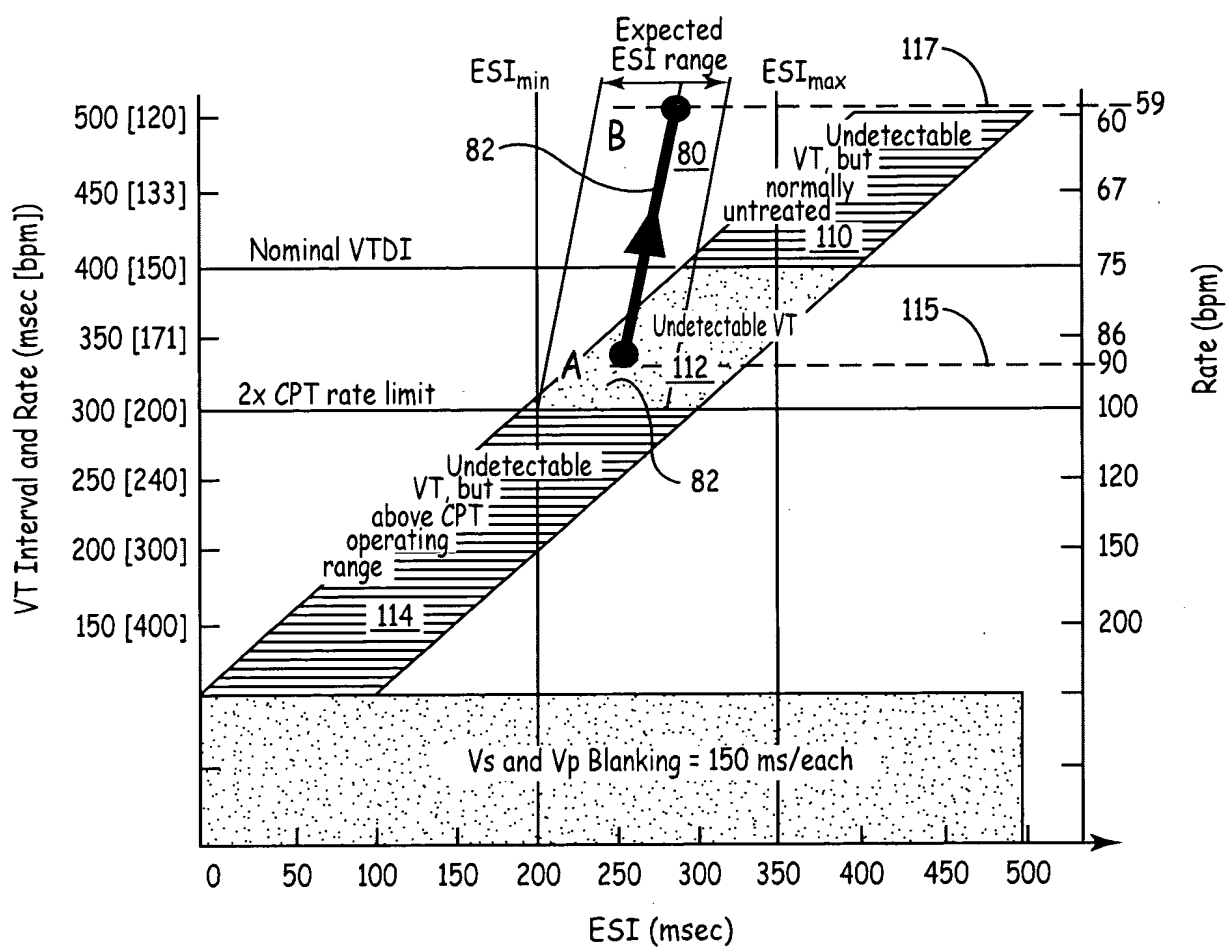
VT Detection and further Extended Operating Range (to 90 bpm)



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FIG. 11

Transient Override of Rate Limit to Permit Mediated Rate Reduction



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FIG. 12

